THE BELL SYSTEM TECHNICAL JOURNAL

DEVOTED TO THE SCIENTIFIC AND ENGINEERING ASPECTS OF ELECTRICAL COMMUNICATION

Volume 53 | January 1974 | Number 1

Automatic Intercept System:

Organization and Objectives

By C. J. BYRNE, W. A. WINCKELMANN, and R. M. WOLFE

(Manuscript received April 12, 1973)

The Automatic Intercept System routes calls to nonworking telephone numbers to a centralized location where a time division network under stored program control connects the calling customer to a series of prerecorded announcements. The customer is told what number he reached and, from information stored in a large-capacity disc file, is given the reason the number is not in service and, if available, the new number at which the called party may be reached. This paper describes the system objectives and organization and also serves as an introduction to the detailed papers which follow.

I. INTRODUCTION

1.1 General

Each customer's line in the telephone switching network is identified by a unique seven-digit number within a three-digit area code. The first three digits designate the local switching center or "office" in which the customer's line terminates, and the remaining four digits identify the customer within that switching center. Of the 10,000 possible telephone numbers associated with an office code, some 1000

or more are not actually assigned at any given time. Many numbers have been disconnected as customers move, other numbers have been changed, and some offices are only partially equipped, with blocks of numbers not existing in a particular office.

When a number assignment is discontinued for any reason, the number cannot immediately be reassigned. If it were, the new customer would receive calls for the person formerly assigned that number, resulting in confusion and irritation to both parties. For this reason, a discontinued number is held out-of-service until the rate of incoming calls has decreased. The period of time can be over 12 months in the case of changed business numbers. Calls to a discontinued number are intercepted in the terminating office, and the calling customer is told why the number is no longer in service and, if possible, given a new number at which the called party may be reached.

In most dial central offices, there are three categories of intercept. Calls to recently discontinued numbers where a new number for the called party is available represent one class of intercept service, which is designated "Regular Intercept." Another class of intercept, called "Machine Intercept," is the result of calls to disconnected numbers where no new number is available, numbers not actually existing in partially equipped offices, numbers which are equipped but have never been assigned, or numbers which have been discontinued for a long enough period of time to be considered unassigned.

The third class, designated "Trouble Intercept," is used when essential customer lines are temporarily out-of-service due to trouble, and alternate means of reaching those customers have been established.

1.2 Present methods

At the present time, most large dial central offices route intercepted calls to a central point over dedicated intercept trunks. The class of call is indicated by the type of supervisory signal used to seize the trunk to the central point. Machine Intercept calls are connected to a recorded announcement, which notifies the customer that he has reached a number which is not in service and asks him to stay on the line if he requires further assistance. If he does not disconnect within a timed interval, he is switched to an intercept operator. Regular Intercept calls are routed to the same point, but are immediately switched to the intercept operator without receiving a recorded announcement. Trouble Intercept calls are routed to a special switchboard location where an operator has been instructed in assisting customers to reach the called party.

When a call is switched to an intercept operator, the operator asks the customer what number he is calling, consults a printed record of nonworking numbers, and gives a verbal report to the customer of the status of the number with any available new number information.

Some small dial offices route intercepted calls to switchboard operators over general-purpose trunks. These offices do not distinguisb separate classes of intercept calls, but mark all intercept calls with a burst of audio tone derived from a ringing machine. The operator may serve the customer by reference to an intercept bulletin or may forward the call to an intercept bureau over a dedicated trunk.

Studies of this present method of handling intercept indicated that the development of more automatic means would provide better customer service and would also result in cost savings.

From a cost standpoint, approximately 3500 Bell System operators are required for the time-consuming process of answering calls, searching the intercept record, and giving verbal reports. The record of intercepted numbers, because of the volume of changes, must be reprinted and delivered to each operator position daily. Entries in the record are subject to a time lag as well as to clerical errors.

From the customer's viewpoint, the nonworking number announcement may cause confusion. Customers intending to dial a working number occasionally make an error in dialing. With about 15 percent of the available numbers on intercept at any given time on tbe average, the customer has a good chance of reaching intercept. If the number is on Regular Intercept, the customer gives the operator the working number he intended to dial. The operator finds no entry in the record for that number and reports "That is a working number. Will you dial it again, please?" If tbe number dialed happens to be on Machine Intercept, the customer receives an announcement telling him that he has reached a number which is not in service. If he does not disconnect, an operator then asks for the number and tells him it is a working number, contradicting the previous machine announcement.

II. OBJECTIVES

The objectives of the Automatic Intercept System (AIS) are:

(*i*) To improve customer service while saving operating costs by automatically identifying the number actually reached and giving the necessary information to the customer by means of an automated announcement.

The recorded announcement should give all necessary information to the customer and eliminate operator intervention

on most calls. In addition to the called number, it should include the status of that number (changed, disconnected, etc.), and the new number with the new area code or new geographic location when required. Operator assistance should be needed only when a customer is not satisfied after hearing an announcement or where calls cannot be handled by the automated announcement.

Figure 1 shows some typical recorded announcements as provided in the AIS. The first announcement sequence is used for a disconnected number with a transfer of calls to a new number. The second announcement is used for a call to an unassigned number. The home area code is included optionally in case a distant customer has reached this number by dialing a wrong area code. The third sequence is used for a number change with a new number and includes the geographic area in which the new number is located.

(*ii*) To save the cost of printing intercept records by providing a mechanized data base.

The means of maintaining the data base should have the capability for rapid record updating, with immediate online insertion, deletion, and verification of record entries.

III. OVERALL SYSTEM CONFIGURATION

Figure 2 is a diagram of a typical Automatic Intercept System. Local terminating offices are designated "ANI" (for Automatic Number Identification) where the local office has been modified to

THE NUMBER YOU HAVE REACHED, 642 54 31, HAS BEEN DIS-
CONNECTED. CALLS ARE BEING TAKEN BY 747 36 45. PLEASE
MAKE A NOTE OF IT - 642 54 31 HAS BEEN DISCONNECTED. CALLS
ARE BEING TAKEN BY 747 36 45. IF YOU NEED ASSISTANCE, YOU
MAY STAY ON THE LINE AND AN OPERATOR WILL ANSWER.

THE NUMBER YOU HAVE REACHED, 368 11 HUNDRED, IS NOT IN
SERVICE IN THE 201 AREA. PLEASE CHECK THE NUMBER AND DIAL
AGAIN. 368 11 HUNDRED IS NOT IN SERVICE IN THE 201 AREA.
IF YOU NEED ASSISTANCE, YOU MAY STAY ON THE LINE AND AN
OPERATOR WILL ANSWER.

THE NUMBER YOU HAVE REACHED, 432 98 72, HAS BEEN CHANGED.
THE NEW NUMBER IS 741 32 32 IN THE RED BANK AREA. 432 98
72 HAS BEEN CHANGED. THE NEW NUMBER IS 741 32 32 IN THE
RED BANK AREA. IF YOU NEED ASSISTANCE, YOU MAY STAY ON
THE LINE AND AN OPERATOR WILL ANSWER.

Fig. 1—Typical Automatic Intercept announcements.

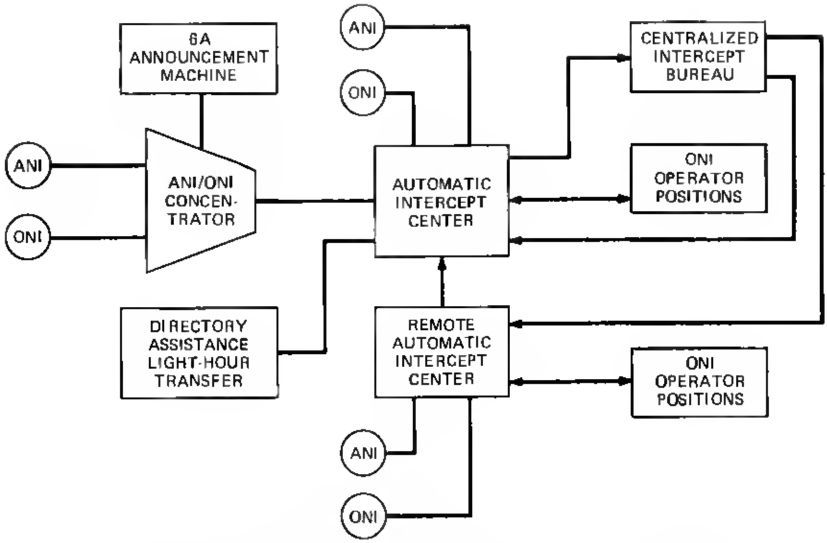

Fig. 2—Overall system configuration of an Automatic Intercept System.

identify and outpulse to the Automatic Intercept Center (AIC) the seven-digit called number with a one-digit prefix indicating the class of intercept (blank, regular, or trouhle). Offices designated "ONI" (for Operator Number Identification) are not so modified. Calls from these offices are switched through the AIC to an ONI operator who interrogates the calling customer and keys the called number into the AIC, after which the call is handled as if the called number had been outpulsed from the local office.

The following types of offices can he modified for ANI operation:

No. 1 Electronic Switching System
No. 2 Electronic Switching System
No. 1 Crossbar Dial Offices
No. 5 Crossbar Dial Offices
Step-by-step Dial Offices equipped with certain Automatic Numher Identification features used for Automatic Message Accounting
Panel Dial Offices equipped with Automatic Numher Identification features used for Automatic Message Accounting.

Modification of electromechanical local offices for ANI is a major cost factor in the Automatic Intercept System, hut the cost is recoverahle through operator savings. ESS offices are modified simply by exercising

a feature option in the generic program. The cost of providing ANI features for all types of new office installations is relatively small.

The AIS is made compatible with the three-class ONI operation to allow installation and cutover of an AIS with unmodified local offices. This provides for early realization of operator savings while permitting orderly scheduling of modification activity at the many local offices connected with each AIC. It also allows offices which are scheduled to be replaced within a few years to use AIS service without modification.

In addition to the ANI and three-class ONI connections to the AIC, one-class ONI operation is provided, which treats all seizures as "regular" ONI intercept calls. This feature is used for calls from local offices not arranged to indicate class of intercept and for operator-forwarded calls.

Calls may be routed to the AIC via direct two-wire trunks or carrier facilities. Trunks from a group of offices located at a considerable distance from the AIC can be concentrated to save on trunk costs. Since intercept traffic from an individual local office is of the order of 0.5 erlang and since several intercept trunks must be provided for an adequate grade of service, allowing for maintenance outage, the average trunk usage is of the order of 20 percent. Concentrating trunks from several local offices results in savings in trunk costs from the concentrator to the AIC.

The No. 23 concentrator (with modifications) can serve a mix of ANI and ONI local offices. It can be equipped for a maximum of 140 incoming trunks and 40 outgoing trunks. Machine Intercept calls can be routed to an announcement machine at the concentrator, with calls from customers who wait through the announcements forwarded to the AIC for operator handling. This feature may be used to deload the AIC network by diverting "machine" ONI calls.

An AIC may also handle Directory Assistance (411) calls transferred from Directory Assistance bureaus during periods of light traffic. These calls are routed to Centralized Intercept Bureau (CIB) consoles with a displayed indication of an incoming Directory Assistance call. Shelf space is provided at the console for directory records. Directory Assistance calls must be routed through dedicated Directory Assistance trunks and cannot be mixed with intercept calls.

Calls may route to a "Home" AIC, which has associated CIB operator consoles, or to up to four "Remote" AIC's which contain all facilities except CIB consoles. Calls in a Remote AIC requiring operator assistance or light-hour Directory Assistance are transferred

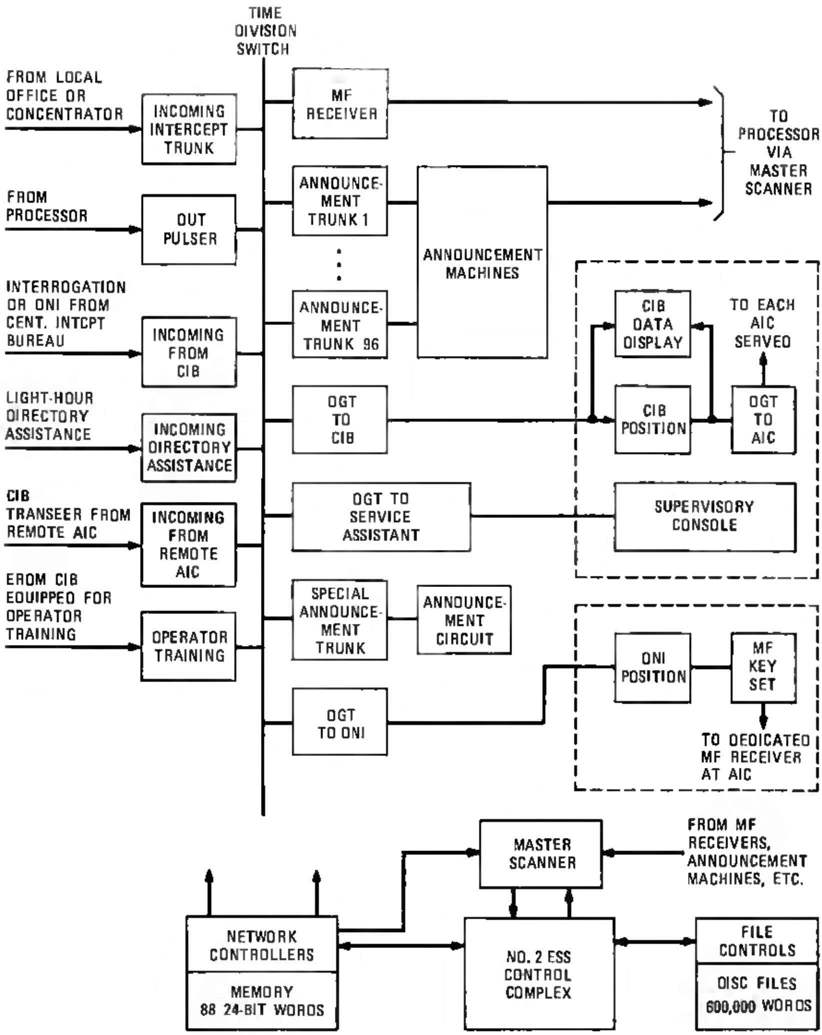

Fig. 3—Block diagram of an Automatic Intercept Center and operator positions.

to the CIB through the Home AIC on a tandem basis. CIB operators have access to each AIC served and may interrogate any AIC using a position keyset to receive a display or announcement based on the information stored in the data file for any seven-digit number.

Calls requiring the ONI function may be routed to special ONI operator positions or may be routed to the CIB positions. Installations

with relatively little ONI traffic would find it uneconomic to provide two separate operator teams. For example, an installation which can be served by six ONI operators and six CIB operators can be served by ten operators at CIB positions because of the increase in efficiency at the larger team size. However, the savings in operator costs are partly offset by the cost of the additional CIB positions, which are equipped witb an automatic display capability which is not needed for ONI positions.

When ONI positions are equipped, ONI calls in a Home AIC can be routed to the CIB positions during ligbt-traffic periods. A Remote AIC handling ONI traffic must be equipped with ONI positions and cannot route calls to the Home AIC for the ONI operation.

IV. AUTOMATIC INTERCEPT CENTER

The configuration of the AIC is sbown in Fig. 3. The AIC consists primarily of a control complex, Master Scanner, switching equipment, announcement machines, and disc files.

4.1 Control complex

The control complex is identical to that used in the No. 2 Electronic Switching System.[1] It is composed of two Control Units and a Maintenance and Administration Center. The Maintenance and Administration Center is described in Section VII. Each Control Unit includes a Program Control, Program Store, Call Store, and Input-Output Control (see Fig. 4).

4.1.1 Program Control

The Program Control is a discrete-component solid state processor with a 3-microsecond cycle time. The Program Control reads and executes 22-bit instructions stored in the Program Store, a read-only permanent magnet twistor memory. Each read requires 6 microseconds. The Call Store is the temporary memory. It is a destructive-readout ferrite sheet memory using 16-bit words.

4.1.2 Input-Output Control

The Input-Output Control shares Call Store access with the Program Control and performs time-critical functions such as digit receiving and data outpulsing. It also provides an interface with peripheral units. The following types of interfaces are provided:

(*i*) A Peripheral Unit Address Bus, shared by all peripheral units, provides for 36-bit (parallel) commands.

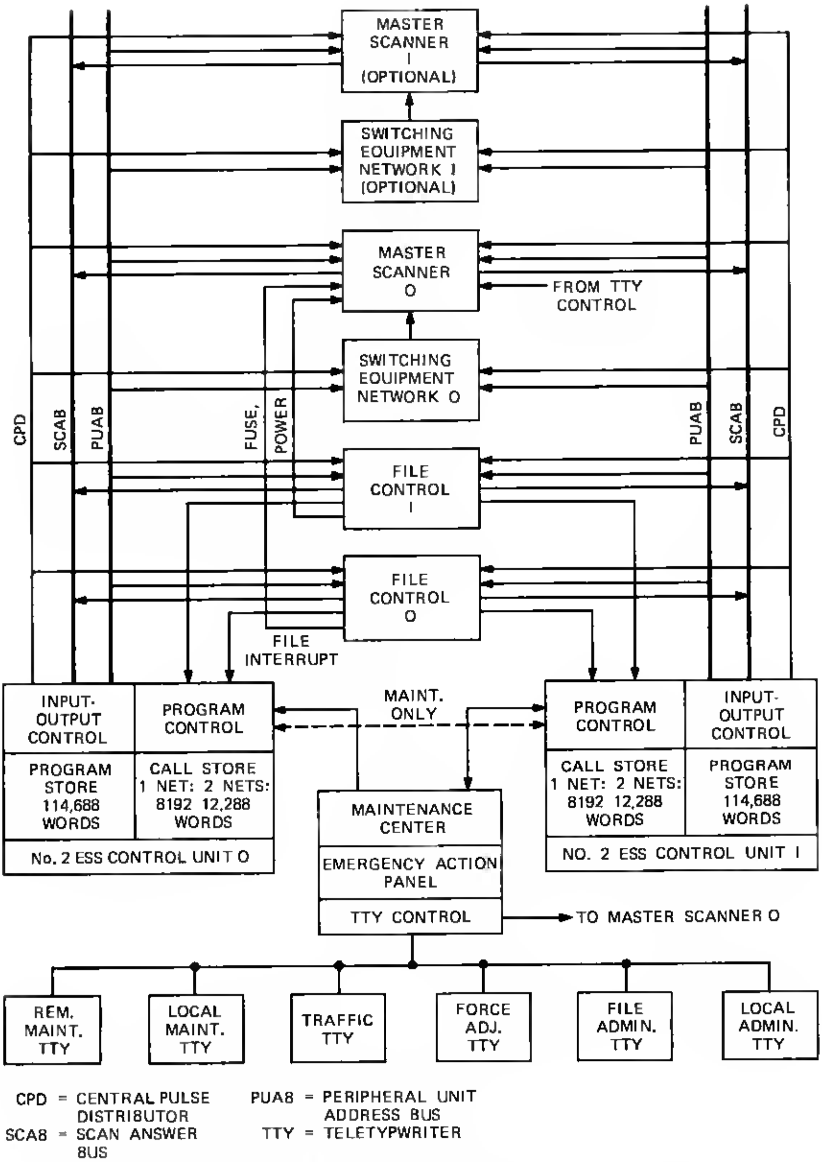

Fig. 4—Processor configuration and interfaces with peripheral equipment.

(*ii*) The Central Pulse Distributor provides communication to peripheral units over dedicated twisted-wire pairs. This device alerts peripheral units to accept commands from the Peripheral

Unit Address Bus. It also transmits single pulses or a short series of coded pulses to peripheral units without use of the Peripheral Unit Address Bus.

(*iii*) The Scan Answer Bus allows the Master Scanner and disc files to reply to a Peripheral Unit Address Bus command. It provides a 16-bit (parallel) word.

4.1.3 Input-output interrupt

An input-output interrupt occurs every 25 milliseconds to allow time-critical programs, primarily associated with peripheral unit access and control, to run.

4.1.4 File Interrupts

One interrupt which is initiated by an external signal is provided for each disc file to provide for receiving a block of information directly from the rotating file.

4.2 Master Scanner

The Master Scanner is an input device which allows the processor to interrogate the dc-current-level state of up to 1024 wire pairs by means of ferrods. It carries all data sent from the switching equipment to the processor (including supervisory reports and digits received by multifrequency or *Touch-Tone*® signaling) and all teletypewriter input messages. It also serves a number of miscellaneous functions.

4.3 Switching equipment

The switching equipment consists of a time division switching network, trunk circuits, multifrequency (MF) receivers, data outpulsers, the service observing terminal, and a trunk test frame.[2] The time division switch, derived from the No. 101 Electronic PBX 2A Switch Unit, was selected because its nearly 100-percent solid state design is well-suited to the high switching rate required for announcement synthesis. Most of the calls in progress require connection changes within a 25-millisecond interval every 0.5 second. The switching network connects the incoming trunk to MF receivers, operators, or announcement tracks as required. Each switching network can accommodate 64 simultaneous connections.

The AIC can be equipped with either one or two switching networks, depending on the traffic required. The switching equipment is so designed that trunks and service circuits can be added, deleted, or changed without wiring changes, within frame capacity limits. This

means that these changes are completely under Operating Company control.

4.4 Announcement machines

The announcement machines store prerecorded words and phrases on a rotating drum coated with a magnetic material. The audio signal on each track is read and amplified in a separate channel and made available at the switching network.

Announcements are synthesized by switching the customer's trunk from track to track as required. The number of tracks provided is 96; 48 tracks contain words and phrases used for standard intercept announcements and 48 tracks are available for geographic locations recorded specially for each installation. Alternately, the letters of the alphabet which appear on a telephone dial can be recorded on 24 of the last 48 tracks. This feature allows synthesis of telephone number announcements with the alphabet central office codes, where such designations are still in use.

The design of announcements must consider the structure of the announcement machine. An announcement is divided into 1.5-second modules. Each 1.5-second module is subdivided into 0.5-second modules. Stock phrases such as "The number you have reached" or "is temporarily out-of-service" are rendered in 1.5-second intervals and can flow smoothly across 0.5-second boundaries. Individual words (including numbers and letters) are recorded in 0.5-second intervals. Once a long (1.5-second) phrase is used in a given message, all further long phrases must be spaced from it by an integral multiple of 1.5 seconds.

Certain rules must be observed to preserve the naturalness of the message. Among these are:

(*i*) Inflections must be appropriate. For example, all numbers are recorded in two inflections, neutral and falling. The falling inflection is used for the third and the last digit of a telephone number.

(*ii*) Pauses must be inserted to break up the word and phrase units into natural thought groups. They also serve to emphasize adjacent words. Pauses are provided by connecting the customer's trunk to a quiet termination.

The timing of the recorded messages is such that only 50 milliseconds of quiet is provided at the beginning of each track to allow for switching. A clock signal is recorded on the drum and signals the start

of a 0.5- or 1.5-second interval to tbe processor by way of tbe Master Scanner. During the next input-output interrupt (within approximately 25 milliseconds), connections to the next track in the announcement sequence are made. The design of tbe switching network is such that the change in track is made in between time division samples, so that no audible click is present.

4.5 Disc files

A record of each equipped intercepted number in the local offices served by an AIC is maintained in duplicated magnetic disc files.[3] This record includes the seven-digit called number, a two-digit status indication, a count of calls to the number, and, when required, a seven-digit new number and three-digit new numbering plan area (NPA) or geographic location.

A disc file is consulted by tbe processor on all calls of the Regular Intercept class, and the reply from the file is used by tbe stored program to connect the proper sequence of phrases and digits to the incoming trunk. Delays, transfer to an operator, or connection to a locally recordable special announcement may be included in a call handling sequence.

On calls to numbers on Machine Intercept, Trouble Intercept calls, or on failure to identify the called number (as indicated by a prefixed digit transmitted by the local office) the processor determines the announcement sequence or other metbod of handling the call without reference to the disc file.

Disc file updating facilities are provided by teletypewriter and data link input with a verification readout to the updating channel.[4] The updating channels also have the ability to obtain a readout of stored information or call counts of an individual number or on all numbers in any local office. The file system also has the ability to match information stored in the two files with a printout of mismatches, or to transfer all stored information from one file to the other.

4.6 Teletypewriters

Operational human interaction with an AIC is primarily through teletypewriter channels. The following channels are provided:

(*i*) Two maintenance control channels, one local and one remote.

(*ii*) A traffic administration machine for control of entries in the disc file intercept record by keyboard or punched tape.

(*iii*) A plant administration machine for initialization, control, and backup of nongeneric data on the disc file.

(*iv*) Two receive-only machines which print out data on traffic volumes and equipment usage for engineering information and operator force adjustment.

4.7 Equipment

All equipment is mounted on No. 1 ESS type frames. Every effort was made in the development of the AIC to minimize line engineering, manufacturing, installation, and maintenance costs. To achieve this, maximum use was made of frames and apparatus previously designed for other systems, options were kept to a minimum, most interframe cabling was connectorized, the use of plug-in apparatus was emphasized, and fixed floor plans were developed.

V. OPERATOR POSITIONS

CIB operator positions provide a visual display to the operator when a customer is connected. The display presents all relevant information on the history of the call. This saves both operator and customer time and allows the operator to concentrate on the customer's problem rather than asking for information already available.

The information for the display is passed from the processor to the operator position over the position's dedicated outgoing trunk by means of frequency-shift keying. A data outpulser is connected to the trunk through the switching network in order to send the display data. The data outpulser connection is then taken down and the incoming trunk is connected to the operator position.

When the AIC network is used as a tandem switching point to switch calls to the centralized operator positions from Remote Automatic Intercept Centers, the data outpulsing is done by the AIC which first received the call and includes the identity of that AIC.

Operators at CIB positions can access a Home or any associated Remote AIC. They can request a display or announcement on any number by keying the digits over trunks to any associated Remote AIC.

ONI operator positions provide a talking connection to an audio trunk and a keyset equipped for MF pulsing over a separate trunk to a dedicated MF receiver at the AIC.

Both ONI and CIB positions can he remote from the AIC. Carrier facilities may he used if the distances are great.

VI. STORED PROGRAM

The program which controls the processor uses approximately 100,000 words of storage. Of these, 21,500 words are used in common

by the AIS and by the No. 2 ESS Local Switching Office. The common code is primarily concerned with processor maintenance, teletypewriters, and utility functions.

The AIS program is totally generic; that is, the program in any installation can provide all optional features and no information which is particular to an individual installation appears in the Program Store. Nongeneric data, such as the assignments and types of individual trunk circuits (translation data) and lists of options, are stored in the Call Store. Since the Call Store is a volatile medium, nongeneric data are backed up on the disc file.[5]

This method of storing nongeneric data allows the administration of nongeneric data to be accomplished locally, by means of teletypewriter messages. There is no requirement for writing permanent magnet twistor cards locally or for a centralized office data assembler facility. This results in a savings in equipment and operational manpower over storing nongeneric data in the permanent magnet twistor memory.

Nearly all programs run at base level. Functional groups of programs are run in sequence until each group has been accessed (through its monitor); then the sequence is restarted. Each sequence is called a main program loop.[5] The time required for a single main program loop can run from about 12 milliseconds to the order of 200 milliseconds, depending on the work to be done.

Time-critical programs (primarily concerned with input-output functions) run in interrupts. Each interrupt stops current base-level work and restarts it when the interrupt program completes its work.

All transient data, including records of calls in progress, are kept in Call Store. Each call is assigned a Call-In-Progress Register (CIPR), which is an eight-word block of Call Store. Nearly all pertinent information about a call is kept in the CIPR. CIPR's in use are examined by call processing programs once each base-level loop to see if further action on the call is required. Counts of calls handled and usage counts are kept in the Call Store and printed on the traffic teletypewriter at 15-minute or half-hourly intervals.

VII. MAINTENANCE FEATURES

Duplicate units are provided for all service-critical components except the switching network, which has a soft-failure mode, in that some worst-case single faults can reduce the traffic capacity by one-half of one network.

The duplicate processors normally run in synchronism, with one online and the other offline.[1] The outputs of the offline processor are inhibited from activating any external equipment, but both units are executing the same sequence of instructions and both Call Stores contain identical information. On eacb write into Call Store tbe data being written are matched in tbe maintenance center. A mismatch causes error detection tests to be run on the online unit. If tbese tests fail, the unit is switched offline and tbe other unit is switched online and performs diagnostic tests on tbe now-offline processor in addition to taking over operation of the system. If the initially online unit passes its detection tests, it runs a diagnostic on the offline unit.

A processor switch may also be caused by other error checking circuits built into the processor.

Single hard faults in the peripheral equipment are rapidly detected by checks in call processing programs, periodic checks of circuit-detected trouble signals, and maintenance exercise programs. Once a fault bas been detected, working mode programs isolate the affected unit and remove it from service. Diagnostic programs isolate tbe trouble to a few circuit packs and print a maintenance teletypewriter message which indicates the packs to be changed. This sequence of actions is performed in short program segments (usually less than 5 milliseconds in elapsed time) run once per main program loop, so that call processing is unaffected after the working mode action.

The maintenance center provides a means for a maintenance man to communicate with the system. It includes lamp displays of registers and equipment status, control keys, and a teletypewriter for two-way communication with the processors. The local maintenance teletypewriter is backed up by a remote maintenance teletypewriter to allow operation of the system from a distant location.

A daily or hourly count of possible trouble conditions, along with base traffic counts useful in normalizing trouble rates, is printed on the plant maintenance teletypewriters.

VIII. ENGINEERING CONSIDERATIONS

Plans for early installations indicate that the capacity of Automatic Intercept Systems will usually be limited by the number of time slots available to establish connections. A study of the AIS priority queue structure predicts that the capacity of each 64-time-slot network is approximately 1900 busy-hour CCS. Tbe capacity can vary about ± 5 percent from this figure depending on the traffic mix.

Assuming that an installation is network-limited, the number of calls which can be handled by the system depends on the average network holding time per call. The holding time in a Home AIC with no associated Remote AIC and no Directory Assistance traffic depends primarily on the following factors:

(*i*) Proportions of ANI and ONI calls.
(*ii*) Proportions of Regular Intercept and Blank Number calls.
(*iii*) Proportions of Regular Intercept calls which have new number information to be announced.
(*iv*) Handling of ONI calls on CIB or ONI positions (CIB positions require a second network connection for keying).
(*v*) Quality of the intercept data base (errors require operator handling).

Studies of the traffic at the first two installations indicate that the average holding time for AIS installations can range from 15 to 35 seconds, depending on the traffic mix. Assuming an average network holding time of 20 seconds (which is conservative for predominantly ANI traffic), the capacity of a two-network AIC is 19,000 calls per busy hour. Clearly, capacity estimates for future installations must be based on careful counts of traffic by types, with an allowance for reserve capacity which reflects any uncertainty in the number and mix of calls as well as peaking and growth factors.

Measurements of processor usage under live traffic confirms that there will be adequate processor capacity at full load.

When an AIC is loaded to capacity, calls enter a priority queuing structure to assure the most efficient use of resources. When the queue capacity is exhausted, calls are held in the Call-In-Progress Registers and served in random order. When the Call-In-Progress Registers are exhausted, requests for service are not acknowledged until registers become available. Local offices are arranged to time out and give reorder tone to customers when excessive delays are encountered. This sequence of overload provisions assures that throughput will not decrease due to overload.

IX. SAVINGS IN NUMBERS OF OPERATORS

A major objective of the Automatic Intercept System is to save operators. Current manual systems require an operator to perform the following functions:

(*i*) Ask the customer what number is being called.
(*ii*) Look up the number in a bulletin.

(*iii*) Tell the customer why the number is on intercept and give a new number if available.

(*iv*) If the customer feels tbe information is incorrect, fill out a trouble report or transfer tbe call to a service assistant.

The AIS automates steps (*i*), (*ii*), and (*iii*) above for ANI calls and automates (*ii*) and (*iii*) for ONI calls. In addition, many errors in data base are rapidly and automatically reported to the clerical group responsible for intercept records, reducing the work in step (*iv*).

Figure 5 shows the number of operators required to serve intercept traffic as a function of the number of calls per busy hour. In an all-ANI system with 10,000 busy-hour calls, 85 percent of the operators are saved. In an all-ONI system, 50 percent of the operators are saved.

X. STATUS OF AIS INSTALLATIONS

The first AIS installation was cut over for full-time operation at Hempstead, N. Y., on September 13, 1970. By October 18, 1970, the system was handling 17 ANI and 8 ONI local office entities. On November 8, 1970, intercept traffic for the remainder of Nassau

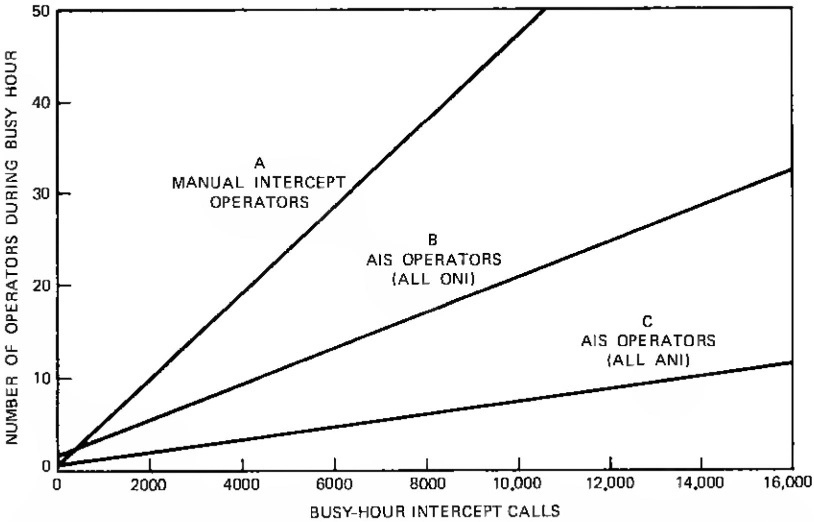

Fig. 5—Number of intercept operators as a function of traffic: curve A, Manual Intercept operators; curve B, AIS operators for an all-ONI system (includes CIB operators and ONI operators at separate positions); curve C, AIS operators for an all-ANI system. The assumptions used in generating these curves are: 40 percent of all intercept calls are of the Machine Intercept class; 10 percent of all calls to manual or ONI operators disconnect while waiting; 5 percent of all intercept calls wait for a CIB operator.

County was transferred to the Hempstead AIS for a total of 33 ANI and 8 ONI entities. At this point, an 18-position Manual Intercept Board was retired.

Between March 7 and April 4, 1971, as local office modifications were completed, all of the Suffolk County traffic was transferred to AIS and a 10-position Manual Board was retired. This AIS in its present configuration serves 3 ONI entities and 71 ANI entities, of which 26 are routed through three concentrators, and also handles Blank Number PBX direct inward dialing for three crossbar tandem units.

The system handles some 90,000 incoming calls on business days, with 250,000 file entries, and 2500 daily changes on disc file intercept records. A force of seven operators handles the busy-hour traffic (which is 97 percent ANI).

The second AIS installation was cut over in Minneapolis, Minn., in October 1971. The third and fourth systems (each equipped with two switching networks) went into service in Cleveland, Ohio, and Manhattan, N. Y., in February and March of 1973. The Indianapolis, Ind., AIS was placed into service in July 1973, and the Baltimore, Md., installation started service in October 1973. Systems are being installed at Newark, N. J., Hammonton, N. J., Miami, Fla., San Francisco, Cal., Washington, D.C., Boston, Mass., Detroit, Mich., Philadelphia, Pa., and other major metropolitan areas.

XI. ACKNOWLEDGMENTS

The design and implementation of the Automatic Intercept System represent the contributions of many groups and individuals at the American Telephone and Telegraph Company, Western Electric Company, and Bell Laboratories. The suggestions of the New York Telephone Company based on their experience with the system also provided valuable information in the design process.

REFERENCES

1. T. E. Browne, T. M. Quinn, W. N. Toy, and J. E. Yates, "[No. 2ESS] Control Unit System," B.S.T.J., *48*, No. 8 (October 1969), pp. 2619–2668.
2. P. J. Brendel, W. K. Comella, R. N. Markson, P. J. Moylan, and J. Orost, "Automatic Intercept System: Peripheral Circuits," B.S.T.J., this issue, pp. 71–106.
3. J. W. Hopkins, P. D. Hunter, R. E. Machol, J. J. DiSalvo, and R. J. Piereth, "Automatic Intercept System: File Subsystem," B.S.T.J., this issue, pp. 107–132.
4. J. H. Carran, K. E. Greisen, W. G. Hall, and D. J. Wells, "Automatic Intercept System: Administering the Intercept Data Base," B.S.T.J., this issue, pp. 133–153.
5. H. Cohen, D. E. Confalone, B. D. Wagner, and W. W. Wood, "Automatic Intercept System: Operational Programs," B.S.T.J., this issue, pp. 19–69.